Abstract

The importance of high wear and fatigue resistance of machine components, used in contemporary machine design, coupled with high fracture toughness and hardness has made it necessary to develop new metallic materials with continually improved characteristics. One novel group of high technology materials with promising fatigue and wear characteristics is conventional metals with advanced treated surfaces.

The weakest part in coated composites is usually the interface and one of the important tasks is to investigate the fracture characteristics of flaws which are perpendicular to the interface. This thesis gives the analysis of the problem of an edge crack penetrating the interface between a coating and a half-plane substrate and its application in modelling the micro-mechanics of fatigue and wear of surface treated metallic components.

A crack penetrating the interface under Mode I and Mode II loading conditions is modelled using the dislocation density function formalism and the Fourier transform method, which render a set of singular integral equations. The model presented in this thesis allows the crack problem to be solved completely, that is the Mode I and Mode II stress intensity factors, the crack face displacements and the complete elastic fields to be determined.

The results for fatigue growth of a surface crack penetrating the prestressed coating and going into the substrate are obtained through a combination of a linear fracture mechanical analysis and a Paris' law description of crack growth. Based on the above a parametric study of fatigue crack growth is presented. The individual influences from the stiffness ratio, the thickness of the coating and the prestressing are investigated. Emphasis is put on a comparative analysis between coated and uncoated substrates.

The results of the theoretical model presented are novel and provide a tool to assess fatigue behaviour of surface treated metallic components, that is predicting the situations of possible fatigue crack growth, and the ability to select combinations of parameters which ensure crack closure.

The rolling wear of a cracked surface treated component is modeled by a frictionless contact between a coated solid containing an edge crack penetrating the interface and a rigid circular indenter. The problem is formulated by the superposition of the solution to the problem of an edge crack, penetrating the interface in a coated substrate under Mode I and Mode II loading conditions, and the solution to the contact problem between an uncracked coated solid and a rigid circular indenter. The parametric study performed shows how the mismatch between elastic properties of the coating and the substrate, the prestressing in the coating, the radius of the indenter and the distance from the contact load influence the Mode I and Mode II SIFs.

The results of this part of the thesis give a qualitative analysis of wear in coated substrates and have practical implications to the design against abrasive wear and contact fatigue of surface treated metallic components.